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Possible hazardous effects of hydrofluoric acid and recommendations for treatment approach: a review

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Abstract: Hydrofluoric acid (HF) is commonly used for conditioning the glass ceramics either prior to cementation or for intraoral repair in prosthetic and restorative dentistry. The present study offers a review of chemical properties of HF used, highlight the possible hazardous effects of this agent, and to recommend the treatment approach for potential risks. Available published information documented in PubMed, Medline, and Picarta literature databases was reviewed. Additional information was derived from scientific reports, medical and chemical textbooks, handbooks, product information, manufacturers' instructions, Internet web sites of the HF manufacturers. No report was found on the incidence of the hazardous effects of HF in dentistry. Reports from other fields presented incidences of acute and chronic symptoms in exposure to HF. While acute symptoms include skin or nail burns, chronic ones involve systemic toxicity, eye injuries, inhalation and ingestion-related symptoms that can be even fatal. HF can be harmful and particularly aggressive to soft tissues, but symptoms may not be apparent immediately after exposure. The hazardous effects are not based on the pH value, but on the toxicity of HF. Potential hazards of HF known from other applications than dentistry should be considered also in dental applications. Especially the clinicians, who often deal with adhesive cementation or repair of glass ceramics, should take necessary precautions for possible hazards of HF.

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The use, application fields and hazardous effects of hydrofluoric acid

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Abstract

The purpose of this review article was to summarize the chemical properties, applications of hydrofluoric acid (HF) used in restorative and prosthetic dentistry as well as in medical or other fields, to highlight the possible hazardous effects of this agent and to recommend the treatment approach for potential risks, based on the published information available. Original scientific papers listed in PubMed, Medline and Picarta up to the end of 2010 on HF were included in this review. The following search terms were used: Hydrofluoric acid, Acid etching, Surface conditioning, Cementation, Ceramics, Fracture, Repair, Hydrofluoric acid burns, Hydrofluoric acid treatment, Hydrofluoric acid etching, Workplace poisoning, Poisoning, Fatalities, Ceramics, Intra-oral repair, Fluorohydric acid, Fluoric acid, and Hydrogen fluoride solution. Scientific reports, medical and chemical textbooks, handbooks, product information, manufacturers instructions, Internet web sites of the HF manufacturers were also referred. In dentistry, HF is most commonly used for conditioning the glass ceramics either prior to cementation or for intraoral repair. Exposure to HF can be harmful and may not be immediately apparent being particularly aggressive for soft tissues. This is not based on the pH value, but on its toxicity. Common routes of exposure are inhalation, dermal exposure and ingestion that lead to the general symptoms of toxicity such as lung injury, skin burns, systemic toxicity and painful necrotic lesions. General symptoms are skin burns, systemic toxication and eye irritation by fume exposure. No report was found on the hazardous effects of HF in dentistry. HF is commonly used to condition the ceramic surfaces prior to cementation or repair. Especially the clinicians, who often deal with glass ceramics, should take necessary precautions for possible hazards of HF.

Keywords Dental ceramics • Dentistry • Hazardous compounds • Hydrofluoric acid

Introduction

A pure and highly concentrated aqueous solution of hydrofluoric acid (HF) was first prepared in 1809 and hydrogen fluoride was first obtained at the end of the 18th century [1,2]. It was known then as a product capable of attacking glass [1,2]. In fact, the etching of glass by acid-treated fluorspar was reported in 1670 [1,2]. Early versions of HF were aqueous solutions, and were used for glass etching, foundry scale removal and manufacturing inorganic fluorides. From 1930 onwards, it was diversely used for fluorocarbon aluminium fluoride production, synthetic cryolite production for the aluminium industry and pickling of stainless steel [1,2]. During World War II, HF was used in alkylation catalysis to produce aviation gasoline and in the manufacture of fluorine to produce UF₆ for isotopic enrichment of uranium [1-3].

HF is the inorganic acid of elemental fluorine. Hydrogen fluoride is produced by the reaction of calcium fluoride (CaF₂) and sulfuric acid in a reaction furnace at 200°C, which is then cooled and stored as a colorless liquid [1,2]. The main source of CaF₂ to produce hydrogen fluoride is the mineral fluorspar. The volatile HF formed is condensed and purified by distillation [1,2]. HF can be produced through processes such as aluminum melting, ceramic production, and phosphate fertilizers. HF may also occur as an impurity in other chemicals or may be produced through the reaction of other chemicals [1]. It is the starting material for the production of most organic and inorganic chemicals containing the fluorine atom, as well as fluorine gas being the most important fluorine compound for industrial use.

HF solutions can be formed when fluoride salts are acidified with other acids in the solutions. As it is a weak acid, hydrogen fluoride in water for instance, is not completely ionized. Its conjugate base, the fluoride ion F⁻, can re-associate to form HF at low pH acid [3]. In the presence of strong acidic solutions, the pH of the fluoride-containing mixture will be low and the free F⁻ formed from the ionization of the fluoride salt in aqueous solution will be quantitatively present as HF. Therefore, soluble fluoride salts in solution with

acids stronger than HF are treated as a solution of HF. Insoluble fluoride salts such as CaF_2 in aqueous solution are a poorer source of HF, as they are limited by the solubility of the salt. However, in aqueous suspensions that are acidified, solubility increases by the presence of the acid, and a significant quantity of HF can be formed [1].

Aqueous HF is commonly formulated for lower concentration products. The major use of aqueous HF is for occupational reasons for etching and polishing glass and ceramics, removal of sand from metal castings and for cleaning processes [3]. Other important uses include laboratory analysis, floor and wall cleaning, fabric rust removal, etching silicon in semiconductors, cleaning stone and marble and manufacturing inorganic fluoride compounds [4,5].

In 1998, HF was acknowledged as a highly hazardous chemical due to its toxic, corrosiveness and reactivity [1]. It can be used in the anhydrous (100%) form or in aqueous solutions where the latter range in concentration from <1% to 70%. Severity and rapidity of onset of signs and symptoms depends on the concentration, duration of exposure and penetration to the exposed tissue. [6]. When accidentally released, HF can diffuse as a dense vapor and aerosol. HF itself is not flammable, explosive or oxidizing but it is a highly reactive chemical. Hence, its storage conditions and handling must be taken into account. Contact with many metals can lead to the formation of hydrogen gas, which forms explosive mixtures in air at concentrations between 4% and 75% [1,2]. The reaction occurs at concentrations of approximately less than 65% of aqueous HF but over time at higher concentrations of anhydrous HF. In closed containers, hydrogen formation can cause dangerously high pressures [6,7]. As the reaction of hydrogen fluoride or concentrated HF with water is exothermic, it may react violently on mixing. Concentrated aqueous solutions can fume in the air and heat is produced upon reaction.

Since the introduction of glass-based ceramics and discovery of the benefits of adhesive cementation in dentistry, HF started to be used to condition restorative and prosthetic devices [8]. Strong bonds can be

formed between resin-based materials and dental ceramics that are etched with hydrofluoric acid (HF) [9]. This is based on the affinity of fluoride to silicon that is higher than to oxygen: $4\text{HF} + \text{SiO}_2 \rightarrow \text{SiF}_4 + 2\text{H}_2\text{O}$. The greatest advantage of the use of HF is that its chair-side application is very simple and for this reason sophisticated conditioning or cleaning methods may not be necessary [10].

The objective of this review article was to summarize the chemical properties, applications of hydrofluoric acid (HF) used in medical or other fields as well as in restorative and prosthetic dentistry, to highlight the possible hazardous effects of this agent and to recommend the treatment approach for potential risks, based on the published information available in the chemical and medical fields.

Materials and Methods

Original scientific papers listed in PubMed, Medline, Picarta up to the end of 2010 on HF were included in this review using the following search terms: Hydrofluoric acid, Acid etching, Surface conditioning, Ceramics, Fracture, Repair, Hydrofluoric acid burns, Hydrofluoric acid treatment, Hydrofluoric acid etching, Workplace poisoning, Poisoning, Fatalities, Cementation, Ceramics, Intra-oral repair, Fluorohydric acid, Fluoric acid, and Hydrogen fluoride solution. Only articles in English were selected. Scientific reports, medical and chemical textbooks, handbooks, product information, manufacturers' instructions, Internet web sites of the HF manufacturers were also referred.

Results

Acute hazardous effects

As with all inorganic acids, due to hydrogen ion degeneration and corrosion, HF burns skin [11-13]. After penetrating the skin, it moves quickly to the deeper tissue layers and releases the freely dissociable fluoride ion. Toxicity of the ion is based on its strong reactivity. The mechanism of HF injury is thought to be binding

of fluoride ions to tissue calcium and magnesium cations to form insoluble salt. These interfere with cellular metabolism, inducing cellular death and necrosis [4]. The precipitation of calcium to form calcium fluoride salts is an unusual property of this acid. HF burns could be as a consequence of the dehydrating effect and the low pH. Skin contact with HF, even dilute solutions (0.1%) can cause painful second and third degree burns that heal very slowly [7]. Burns have a rather characteristic appearance and present as severely reddened, swollen areas with blanched, whitish regions that rapidly progress to blistering and necrosis accompanied with pain [14]. Latent damages could also be observed since fluoride ion penetrates through all layers of the epidermis, dermis, and even the deeper subcutaneous tissues, causing severe destruction, necrosis and injuries to the underlying bone due to decalcification [15]. The effect can continue for several days, causing increasing tissue damage at a later stage. The damage is directly related to the concentration of the acid and the duration of contact. HF burns are classified according to the acid concentrations of 0-20%, 21-50%, and greater than 50% [15-19]. Skin contact with hydrogen fluoride, or solutions containing more than 50% HF, produces immediate pain. Reactions to more dilute solutions (concentration 20-50%) may be delayed for minutes to several hours. The accompanying pain is excruciating and persistent, and healing is delayed [15-19]. Erythema and pain may be delayed up to 24 hours with dilute solutions (<20%).

Many different types of therapies have been suggested for HF burns. The aim of all treatment methods is to chemically sequester the fluoride ion and to prevent extensive, deep-tissue destruction [20]. The first treatment of chemical burns should always be thorough and copious lavage to clean the wound of unreacted surface chemical and dilute that is already in contact with the skin [20]. The second phase of treatment aims to inactivate the free fluoride ion by promoting the formation of an insoluble fluoride salt. It was reported that the calcium ion could decrease the toxic effects of sodium fluoride in tissue [20,21].

Calcium gluconate gel (2.5%) is widely used for first aid and/or primary treatment of HF burns of the skin [22-30]. The gel is applied promptly and repeatedly onto the burned area, up to several hours. Use of

the gel may be more convenient for dilute acid burns that occur with commercial products like rust removers, aluminium cleaners using etching solutions [28]. If good relief of pain is not obtained after 30-40 min, alternative methods of treatment such as calcium gluconate injections or benzalkonium chloride soaks should be considered. Calcium gluconate injection (5%) is indicated for large burns (over 160 square centimeters). Injection of calcium gluconate solution may also be indicated for burns in which initial treatment has been delayed [31-34].

Burns of the fingers and nails permit penetration of fluoride ions but prevent gels from being effective. It may be necessary to drill, split or even remove nails to allow the topical methods of treatment to be effective. However, in less than 10%³ of the burns, removal of the nail was necessary [31-34]. If immersion in benzalkonium chloride (Zephrian[®]) solution is started immediately, it may be possible to avoid removing the nail.

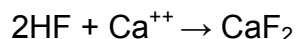
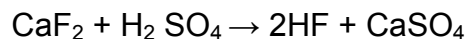
Early aggressive surgery with primary excision of necrotic skin areas has also been recommended as an emergency measure to prevent deep tissue destruction and systemic absorption of fluoride ions [35-41]. When painful indolent ulcer remains resistant to all conservative measures, surgery may be considered with the possibility of unacceptable cosmetics.

Chronic hazardous effects

HF is not classified as a carcinogen since no data exists supporting this. However, increased rates of cancer have been observed in workers exposed to a mixture of chemicals that included fluoride, but no single chemical was identified and reported as the cause of the cancer [13]. Possible effects on reproduction however have been postulated [42]. Occupational studies on women exposed to fluoride identified increased rates of menstrual irregularities. Animal studies also showed that fluoride impairs reproduction and increases the rates of fetal bone and teeth malformation [43].

Systemic toxicity

To produce HF, CaF_2 reacts with sulfuric acid:



This process releases energy and occurs very quickly. Although the pH value of HF is only 3.45, HF is soluble in water by a strong reaction at every concentration. It is very hygroscopic and has the ability to dehydrate substances. It can quickly penetrate into skin and other soft tissues. When HF is exposed in concentrations of about 5% to human skin, initially, in most cases, no pain or other symptoms can be observed, but after several hours a painful burn reaction may become apparent [44-48]. There is some evidence that when fluoride combines with calcium and phosphate, intracellular levels increase [2,44].

Binding of fluoride to body calcium is one of the mechanisms of toxicity of HF. [48-52]. One serious consequence of exposure to HF is the decrease in serum calcium (hypocalcemia) and other metabolic changes, which may result in a fatal outcome if not recognized and treated [57-61]. Hypocalcemia should be considered as a potential risk in all instances of inhalation or ingestion, especially when skin burns exceed 160 square centimeters. Fluoride also binds to potassium and magnesium ions leading to myocardial irritability and arrhythmia. Chronic exposure to HF may cause skeletal fluorosis that can be fatal [53-56]. Hemodialysis has been reported to be an effective therapy for cases of severe systemic intoxication [57,58].

Eye injuries

The eye is highly susceptible to HF liquid or vapour exposures. Contact of HF with eyes may result in permanent eye damage [59-61]. Ocular exposure may denude the cornea and conjunctival epithelium and lead to stromal corneal oedema, conjunctival ischaemia, sloughing and chemosis [59,60]. Deeper penetration of the fluoride ion may cause corneal opacification and necrosis of the anterior chamber

structures. Usually the effects are noted within 3 days, although Hatai et al. described a case of delayed corneal damage, it was not apparent until 4 days after the exposure [60]. Latent complications included recurrent corneal epithelial erosions, keratoconjunctivitis sicca, progressive vascularization of the corneal stroma and symblepharon [59]. As for cutaneous burns, the most important therapy is prompt and efficient lavage. This must be immediate and continued for at least 15-30 min using either water or normal saline [63-66].

Browne advised the use of a few drops of 10 per cent calcium gluconate after irrigation [63]. Trevino et al. recommended 1 per cent gluconate in saline as an irrigant followed by 1 per cent calcium gluconate drops every 2-3 h for several days [64]. They have reported complete recovery using this treatment in 18 out of 19 patients, 13 of whom had completely opacified corneas prior to treatment [63]. Hatai et al. achieved quick, complete recovery of a large corneal erosion caused by 49 per cent HF using a repeated instillation of 1 per cent calcium gluconate drops combined with conventional treatment [60]. Although others also advised the use 1 per cent calcium gluconate drops [41,67] its use remains empirical. McCulley et al. compared irrigation with water, normal saline, magnesium chloride, lanthanum chloride, 0.2% Hyamine, 0.03% and 0.05% Zephiran as well as topical ointments of magnesium oxide and magnesium sulphate [59]. These solutions were also tried as a 1 ml subconjunctival injection. They showed that the only beneficial treatments were irrigation with water, isotonic saline or isotonic magnesium chloride. Procedures involving repetitive irrigation with these agents caused increased rates of corneal ulceration. The same group has also studied the mechanism of eye injury by HF, demonstrating a clear dose-related response [90]. After irrigation it is mandatory to request a prompt ophthalmological opinion. Instillation of cycloplegics to dilate the pupil may be required, and some advocate steroid drops to lessen fibroblast formation in the cornea [64,69]. Rubinfeld et al. are the only group to report the use of debridement of the sloughing necrotic

conjunctiva in an attempt to reduce the fluoride level further and aid in healing [61]. However, speed of delivery of the irrigation remains the most important step among all trials [59].

Inhalation

Inhalation of low concentrations of HF can cause upper airway and eye/skin irritation, and high concentrations can cause serious injury. If inhaled, HF can cause severe respiratory damage, including irritation of the nose, throat, lungs and pulmonary edema [70,71]. Animal studies have also showed increased rates of kidney and liver damage as a result of HF inhalation [42,72-74]. Anhydrous HF is very volatile with a boiling point of only 19.5°C, and even the aqueous solutions (boiling points: 75 per cent HF - 56°C; 60 per cent HF - 89°C) produce a pungent odour. The recommended level of HF in the working atmosphere should not exceed 3 parts per million which could be detected by smelling [75].

A particular hazard, as noted by Mayer and Guelich, occurs when clothing is contaminated since this can produce high concentrations in the inspired air [70]. They reported the case of three workman who died of pulmonary complications following splashes to their cotton clothing with 70 per cent HF, all succumbing within 2 h of the incident. Dieffenbacher and Thompson also reported a petroleum worker whose face and neck were in contact with 10 per cent HF for only 30-35 s [76]. Despite intravenous and subcutaneous calcium gluconate he died 2 h later. Post-mortem findings showed thick mucus with blood in the bronchi, edematous lungs with hemorrhagic patches, and sub-serous hemorrhages in the pleurae. Greendyke and Hodge described similar post-mortem appearances in two men who died following a serious airway exposure to HF of unspecified concentration [77]. High blood fluoride levels were also demonstrated in these patients. Chela and Huguet recorded the murder of a young woman who had HF thrown into her face [78]. She died from acute respiratory insufficiency 3 h after.

Treatment of inhalational injuries begins with removing the patient immediately from the contaminated area and administering humidified 100% oxygen as soon as possible. In an attempt to

neutralize the fluoride ion, some authorities recommend a nebulized solution of 2.5-3.0% calcium gluconate [41,64]. If hemorrhage occurs, then bronchoscopy would be necessary to avoid lobe collapse, and transfusion may be required [66]. Although corticosteroids have been tried they should, be carefully indicated [64,79,80].

Ingestion

The first recorded fatality from fluoride poisoning was in 1873 when King reported the case of a 35-year-old man who died within 35 min after drinking about 15 ml of hydrofluoric acid [81]. This demonstrates the speed of absorption of the fluoride ion by the gastrointestinal tract. Since then many cases of fluoride poisoning have been recorded due to ingestion [82-90]. Initial symptoms often include nausea, vomiting and abdominal pain. Ingestion of even relatively dilute solutions of HF may be rapidly fatal.

Management of HF ingestion is essentially remains the dilution, removal and neutralization of the acid. Stimulation to cause vomiting is not recommended since this may cause further oral, esophageal or pulmonary injury. The patient should be encouraged to drink either water or preferably milk that has been shown to be effective in precipitating fluoride ions in vitro [90]. At the hospital gastric lavage can be considered, some advising the addition of 10% calcium gluconate to the lavage fluid [91].

Death

At concentrations of 30 parts per million (ppm) HF is immediately dangerous to life [70,71]. Fatalities have been reported from a skin exposure to as little as 2.5% of body surface area. Once it penetrates the skin it slowly disassociates into the hydrogen ion and fluoride ion. The fluoride ion affects tissue integrity and metabolism by liquefaction necrosis, decalcification, destruction of bone, and production of insoluble salts. This will eventually result in loss of calcium from the bones. The rapid development of hypocalcemia can be rapidly fatal because calcium is important for muscles, including cardiac muscle. Without calcium, many metabolic pathways are broken down.

Precautions and treatment of symptoms

Ventilation

Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general working area [92]. For emergencies or instances where the exposure levels are not known, the use of a face piece positive-pressure, air-supplied respirator would be useful. It was advised that air-purifying respirators do not protect workers in oxygen deficient atmospheres [92].

Skin protection

Protective clothing with long sleeves, air-inflated suits with masks, goggles, including boots or safety shoes with polyvinyl chloride (PVC) or neoprene should be worn [92].

Eye protection

Chemical safety goggles and/or full-face shields should be used where splashing is possible. Fountains and quick drench facilities should be maintained in the work area [92].

Major symptoms observed after exposure to hydrofluoric acid and the first aid measures are listed in Table 1.

HF use in dentistry and clinical manifestations

HF types and quantities

Concentrations of HF used in dentistry are usually small, ranging between 5% and 15%. They are available either in gel or liquid form. It is indicated to be used both *in-vivo* and *ex-vivo*. While the majority of the HF manufacturers for dental use recommend its use with a rubber-dam, others provide a gel product, the so-

called dental dam to protect adjacent the gingival and soft tissues from HF. In order to avoid the likelihood of HF exposure and to make it more visible, coloring dyes are added to make the product red, yellow or green.

Metals

The application of HF (7.5% and 9.5%) for metals usually takes place in the dental laboratories primarily for stripping and cleaning metals. When a precious metal is cast with a ceramic insert to produce a cylindrical hole that will receive a pin, HF is used to dissolve the ceramic insert to the casting [92].

Ceramics

The most common use of HF in dentistry is for conditioning glassy matrix ceramic surfaces to adhere resin-based materials either prior to cementation or during repairs [94-96,97]. HF selectively etches and dissolves the glass ceramic and cause physical alteration of the surface creating micromechanical retention. The ceramic is then rinsed with water-spray. For cementation purposes, HF etched restoration is placed in neutralizing solution of CaCO_3 and/or NaOCl . HF gel is then further removed in an ultrasonic bath. For intraoral repair applications ultrasonic cleaning of HF is not possible since the restoration cannot be removed [97]. HF application is then followed by silane coupling agent. Acid concentrations and etching times vary depending on the specifications of the ceramics to receive optimized adhesion of the resin-based material.

Composites

Although some manufacturers claim that HF is effective for conditioning resin-based composites also for cementation and repair purposes, poor results were reported [98]. When composites are exposed to HF acid gel, water monolayer may penetrate via voids to fillers that in turn, may disorganize the siloxane network

formed from the condensation of intermolecular silanol groups, which is responsible for stabilizing the filler-resin interface. For this reason, the use of HF acid gel was not found to be a predictable option for conditioning composite materials for repair or relamination purposes.

Acidulated phosphate fluoride

The hazards, caustic effects to soft tissues and the danger for clinical use for hydrofluoric acids are well known by the manufacturers and the researchers. For this reason, some studies questioned whether 1.23% acidulated phosphate fluoride gels might serve as a safe and effective substitute for etching ceramic surfaces to bond composite resin to silanized ceramics [99-101]. It was concluded that 1.23% acidulated phosphate fluoride gels can be substituted for 9.5% hydrofluoric gels as prolonged etching times were required with the lower concentrations of hydrofluoric acid [102]. However, the specimens etched with 4% acidulated phosphate fluoride gel, showed a wider statistical spread than the ones etched with 9.6% HF. This suggested that HF etching might well produce a more reliable and consistent result but this has not been confirmed, as the sample size of these studies was too small [100,102].

Topical fluoride rinses and gels

Therapeutic fluoride products are also applied on teeth for preventive purposes especially in pediatric dentistry. However, HF is a minor ingredient in topical therapeutic fluoride. Required precautions should still be considered using a rubber dam.

Concluding remarks

Since no incidence on hazardous effects of HF has been reported in the dental literature, this literature review led to the conclusion that risks of *in-vivo* and *ex-vivo* use of HF, considering the concentrations used

in dentistry appears to be unwarranted. Since repair actions are rather seldom, particularly the clinicians who indicate glass ceramic restorations would be more likely to be exposed to HF during cementation procedures. For occupational exposure, American Conference of Industrial Hygienists (ACGIH) reported the lowest limits by giving a ceiling value (a limit that should never be exceeded for even an “instantaneous” exposure period) of 3 ppm (2,3mg/m³) (ACGIH 2000). This exposure limit (3 ppm) is also given as 8 hour time weighted average level by Occupational Safety and Health Administration (OSHA 1996). Immediately Dangerous To Life and Health (IDLH) value is given as 30 ppm by The National Institute of Occupational Safety and Health (NIOSH 1996). Concentrated solutions cause immediate pain and produce a surface burn similar to other common acids with erythema, blistering and necrosis [52]. HF concentrations of 14.5% produce symptoms immediately and concentrations of 12% may take up to an hour. Symptoms of 7% HF or less may take several hours before onset of symptoms, resulting in delayed symptoms with the deeper penetration of the HF. Therefore, due to the continuous use of HF in dentistry, the patients should be monitored even after cementation or fixation of the restoration. Knowing potential hazards of HF from other fields, conditioning media other than HF gel have certainly prospective in the future for conditioning ceramic surfaces in dentistry.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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Figure legends:

Tables

Table 1 Major symptoms observed after exposure to hydrofluoric acid and the first aid measures.

Tables:

Exposure	Symptoms	First Aid*
Inhalation	Burning sensation, cough, dizziness, headache, nausea, shortness of breath, sore throat, vomiting	Fresh air, rest
Skin	Redness, pain, blisters	Rinse skin with water, remove affected skin, blisters in serious skin burns
Eyes	Redness, pain, severe deep burns	Rinse with plenty of water for several minutes
Ingestion	Abdominal pain, burning sensation, diarrhoea, nausea, vomiting, weakness, collapse	Rinse mouth

Table 1 Major symptoms observed after exposure to hydrofluoric acid and the first aid measures. *In all cases a doctor should be consulted